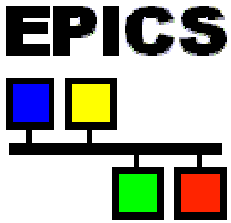


EPICS and LabVIEW

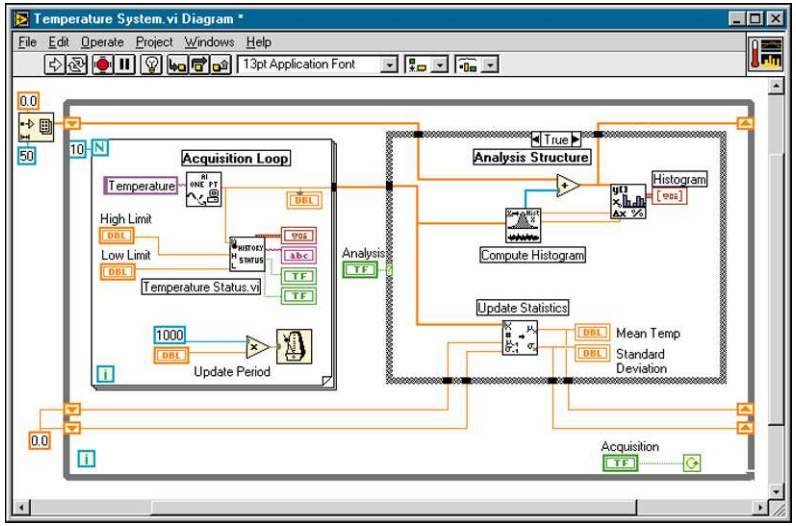
Tony Vento, National Instruments

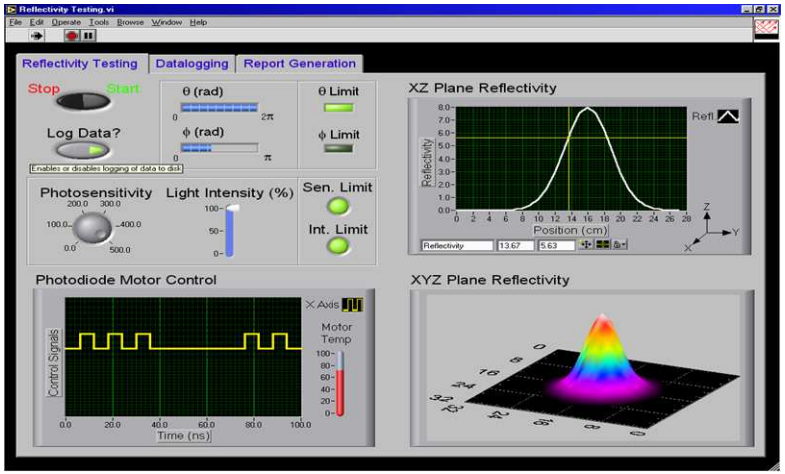
Willem Blokland, ORNL-SNS

NATIONAL INSTRUMENTS LabVIEW™

- Graphical dataflow programming
- Interactive front panel / GUI
- Efficient compiled execution

- Targets
  - Windows, Real-Time, FPGA, Linux, Macintosh, DSP, Other Processors
- I/O and analysis libraries
- Distributed networking capabilities





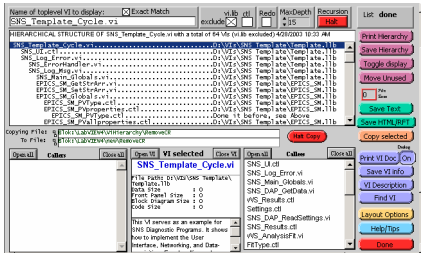
EPICS and LabVIEW Interfaces
(Oak Ridge and Others)

1. Shared Memory Interface to IOC (I/O Channel)
   - Links LabVIEW and IOC Process Variables (PVs)
   - Data from LabVIEW is available to the IOC
   - Windows

2. CA (Channel Access) Client
   - LabVIEW as a display environment for PVs
   - No programming required
   - Windows, Macintosh, Linux

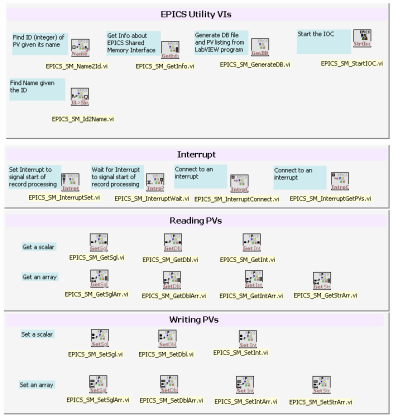
1. Shared Memory Interface

- db & cmd file generator at startup
- Development tool
  -Cloning/documentation



- Shared Memory Records
- LabVIEW Library

(D. Thompson)



Windows PC

Application

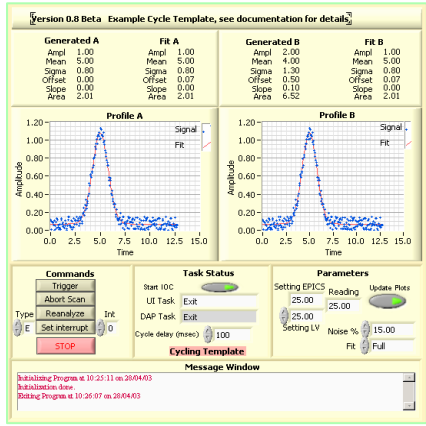
Template tools

LabVIEW

Shared Memory

EPICS IOC+CA

Channel Access



- Standard Examples
- NADs implemented: BCM, BPM, ES, FC, TTS

(M. Sundaram, C. Long, W. Blokland, LANL, BNL)

Graphical programming
- Drivers to DAQ
- Processing routines
- Graphs/Plots

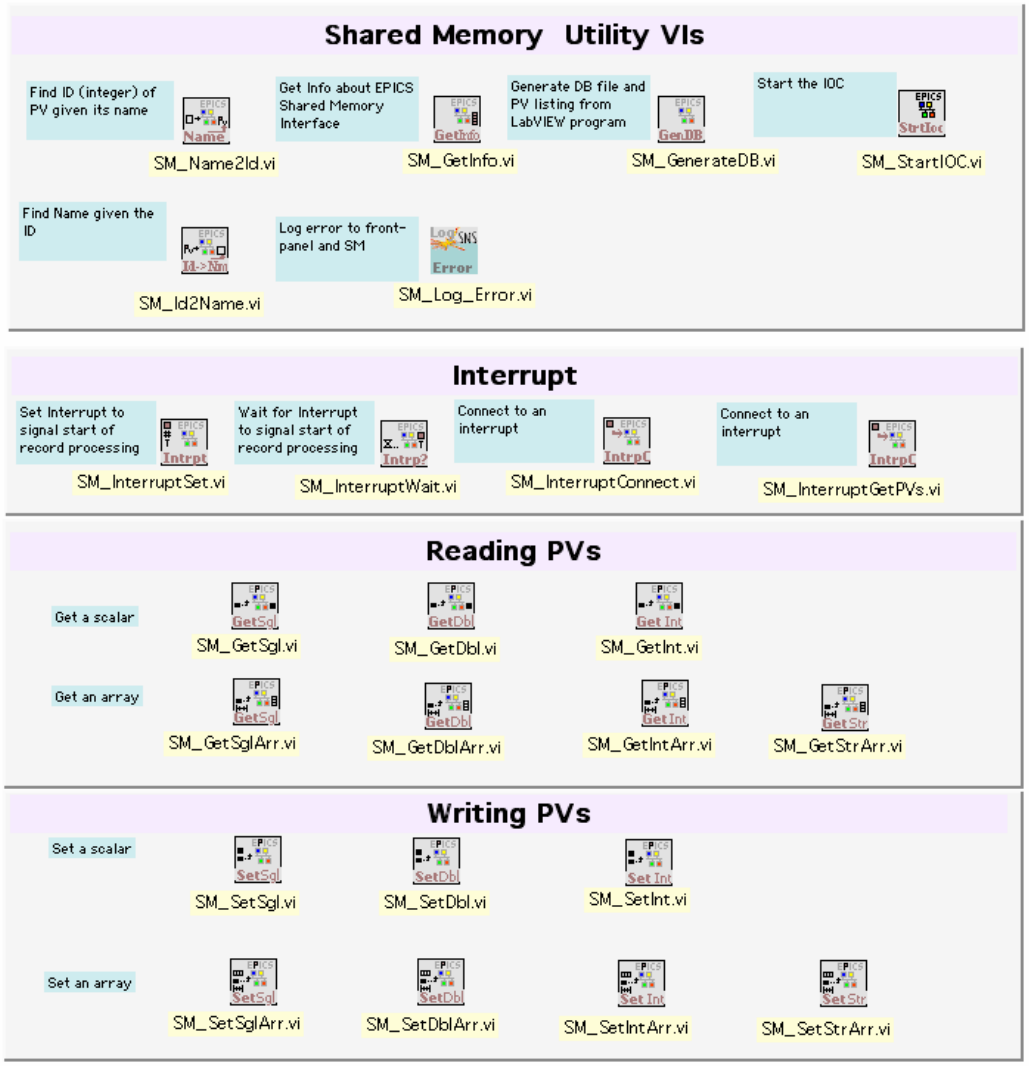
Accelerator Controls

Shared Memory Interface

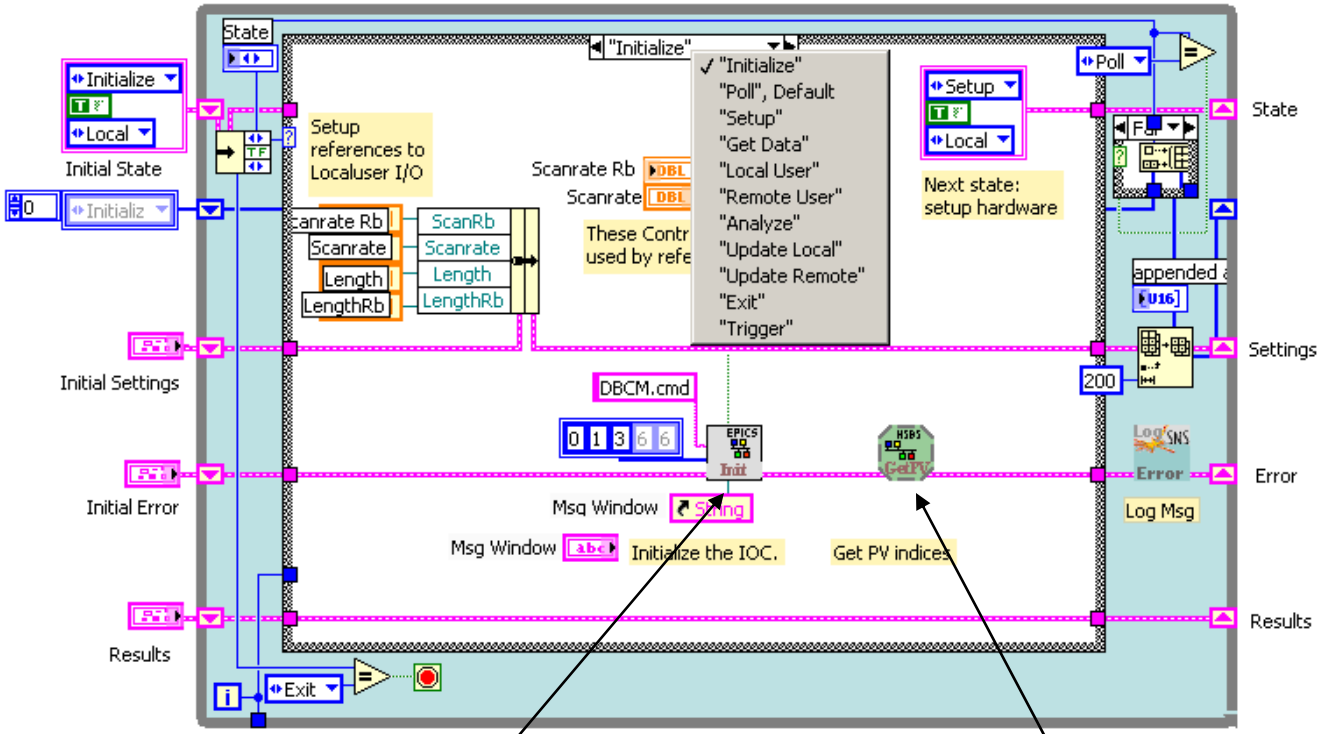
Shared Memory IOC written by D. Thompson. LabVIEW Library by W. Blokland.

The shared memory interface buffers the data and implements functions to:

- **Create, find and destroy variables**
- **Read from and write to variables**
- **Set and receive events**
- **Retrieve information about variables**

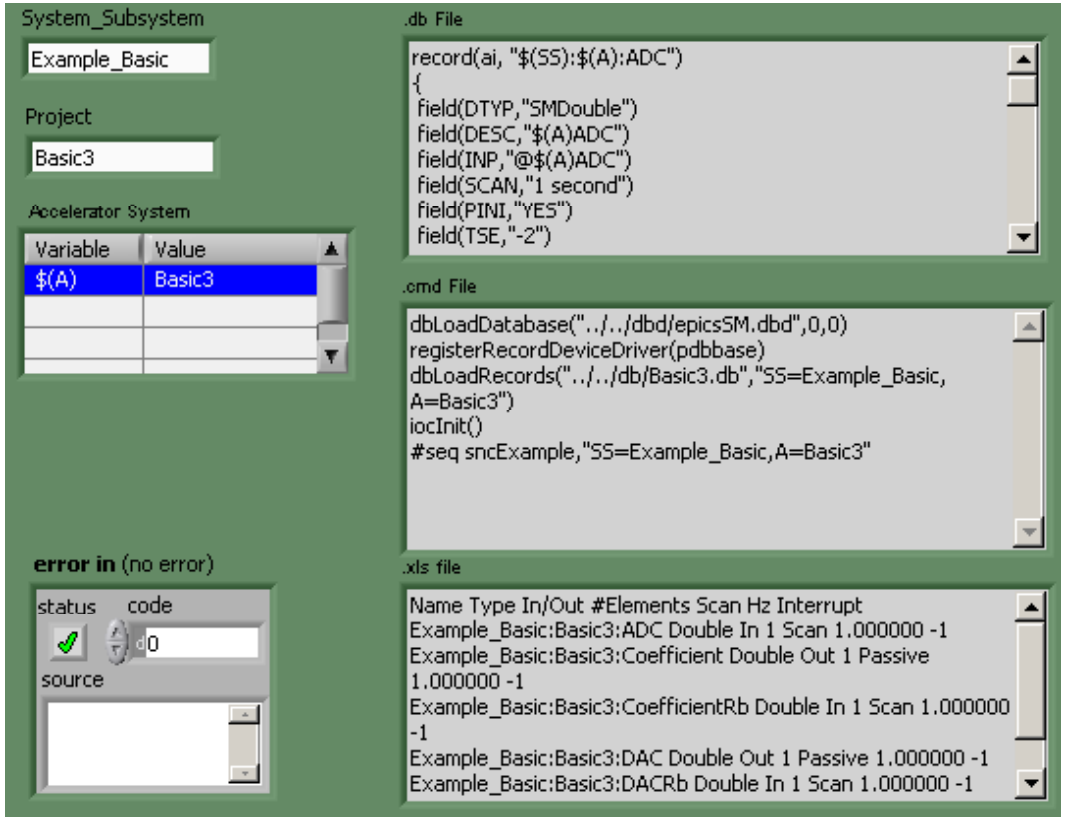


Program startup



1. LabVIEW loads and runs Top-Level VI
2. LabVIEW gets variable declarations, generates .db and starts IOC
3. IOC starts and loads db file. Each time the IOC creates a PV record, the record creates a Shared Memory (SM) entry
4. LabVIEW finds references to SM entries by resolving PV names

EPICS dB Utility



The dBGenerate Utility automatically generates the database file for the EPICS IOC as well as the cmd file and an Excel file. The utility uses the VI that resolves names to indices, as written by the programmer, as information on which PVs are going to be used. The utility supports the instantiation of one device many times (necessary for the NAD concept).

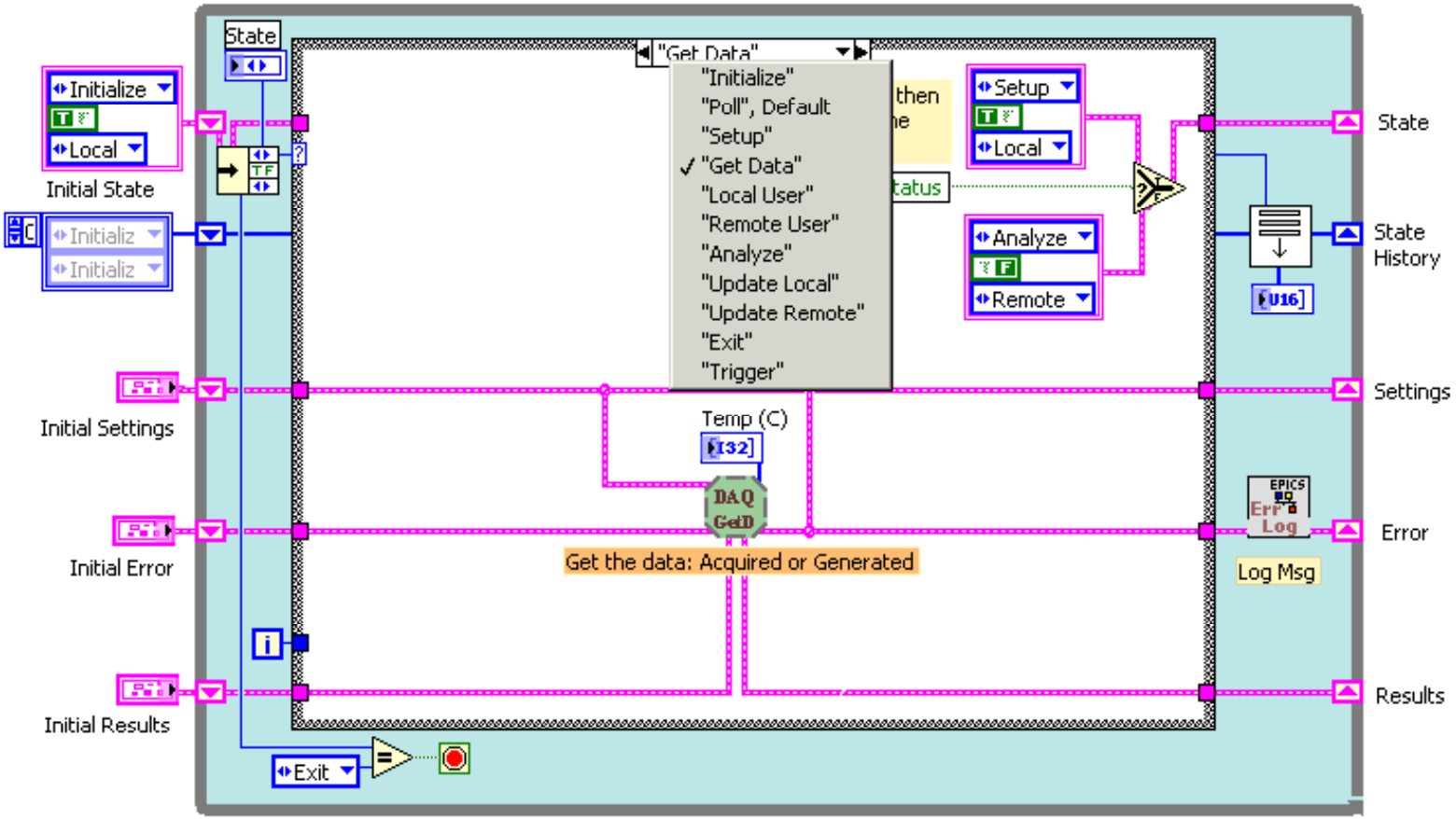
Performance

TEST	Profiler	Total program	Comments
Writing 4096 doubles and setting interrupt to process values	80 usec (+- 10 usec) + 20 usec (+- 5 usec)	270 usec	(2Ghz P4) no client
Writing 1024 doubles and setting interrupt to process values	67 + 11	130 usec (+-10usec)	

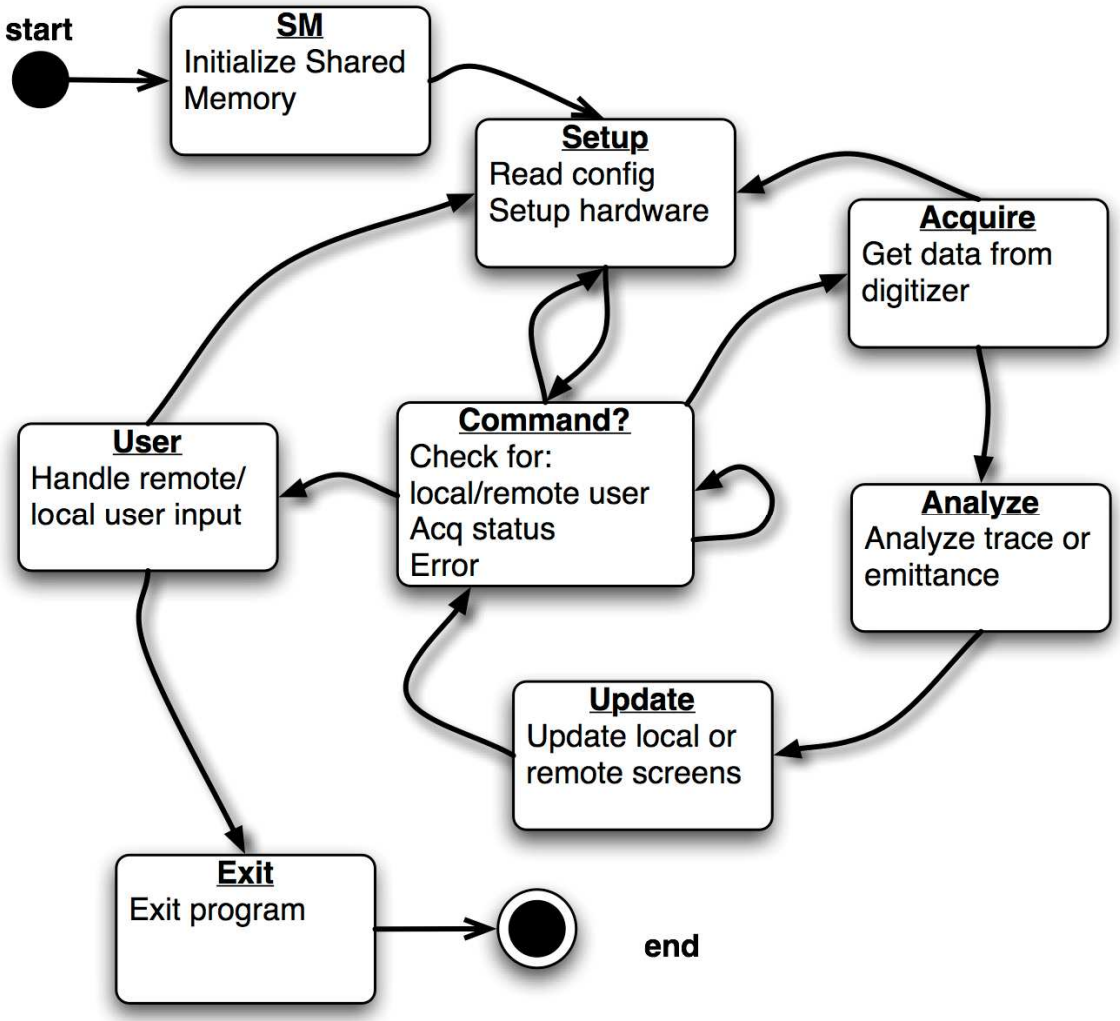
Profiler: times measured with LabVIEW's profiler tool, excludes all time spent by processor elsewhere

Total: use time before and after execution, includes all time spent by processor on other processes.

Template: State Machine



Template: State Machine diagram



Template

Use templates (state-machine based) to:

1) Strict organization -> clear development path
2) Similar structure among instruments-> re-use of code with copy/rename tool
3) Simple structure -> fast development and debug
4) Built-in support for user-interface/EPICS/ configuration files.
5) State machine supports jumps to other state if exception occurs (e.g. error condition)

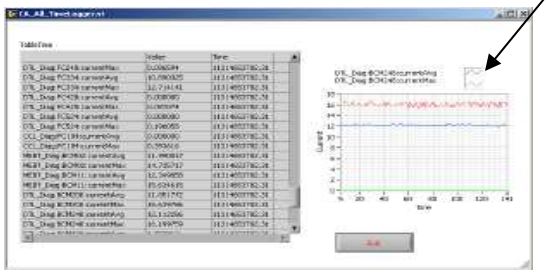
Network Attached Device: Each pickup or sensor has its own resources such as timing, data acquisition and processing. No tightly coupled systems An individual device can fail or be serviced without disrupting other devices. Software is simplified as it doesn't have to manage single resources among multiple devices.

Diagnostic NADs
(Network Attached Device)

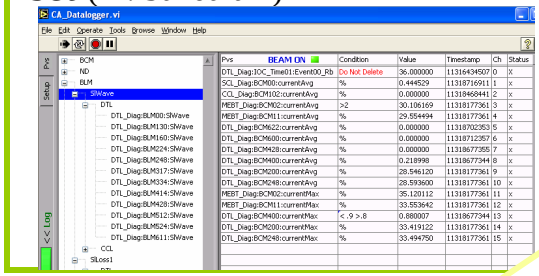
Instrument	Type	Comments	Programmer
Beam Position Linac	IOC	Custom	Blokland/LANL
Beam Position Ring	IOC	Custom	Long/BNL/Blokland
Wire Scanner	CA	Commercial with custom pre-amps	Chistensen (Blokland)
Beam Stop	IOC	Commercial	Blokland
Beam Aperture	IOC	Commercial	Blokland
Faraday Cup	IOC	Commercial	Blokland
Arc Detector	IOC	Commercial	Armstrong/Nesterenko
Source Current Logger	IOC	Commercial	Stedinger
Beam Current Monitor (Linac/Ring)	IOC	Commercial with filter box	Blokland/ArmstrongBNL
Faraday Cup with energy degrader	IOC	Commercial	Blokland/LANL
Halo Scraper/ Beam Stop	IOC	Commercial	Blokland/LANL
Fast Beam Loss Proto	IOC	Commercial	Blokland
Bunch Shape Monitor	(IOC)		INR
Emittance	IOC	Commercial	Long/Blokland
Neutron Detector	IOC	Commercial	Liyu
Physics Test Node	IOC	Commercial	Blokland
Harp	IOC	Commercial	Sundaram
Laserwire transferline	IOC	Commercial	Long
Laserwire beambox	IOC	Commercial	Long
Laserwire video	IOC	Commercial	Nesterenko/Blokland
Video Foil	IOC	Commercial	Armstrong/Blokland/BNL

2. CA (Channel Access) Client

• Drag and Drop Display Client for implementing screens that don't require programming (W. Blokland)



• Tools to select data to log or set (M. Sundaram)



Processing the data.

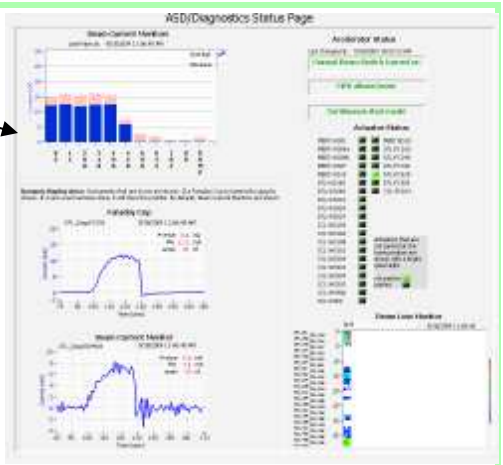
Mac/Linux/Windows

Display | App

LabVIEW

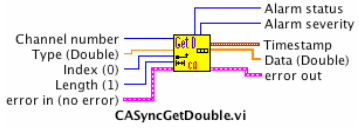
CA/LV Interface

EPICS CA



Examples:
• Channel13: dynamically loaded display modules
• NAD Control screens (W. Blokland, D. Purcell, M. Sundaram)

Multi-platform Interface to buffer CA messages and handle interrupts (A. Liyu)



Channel Access

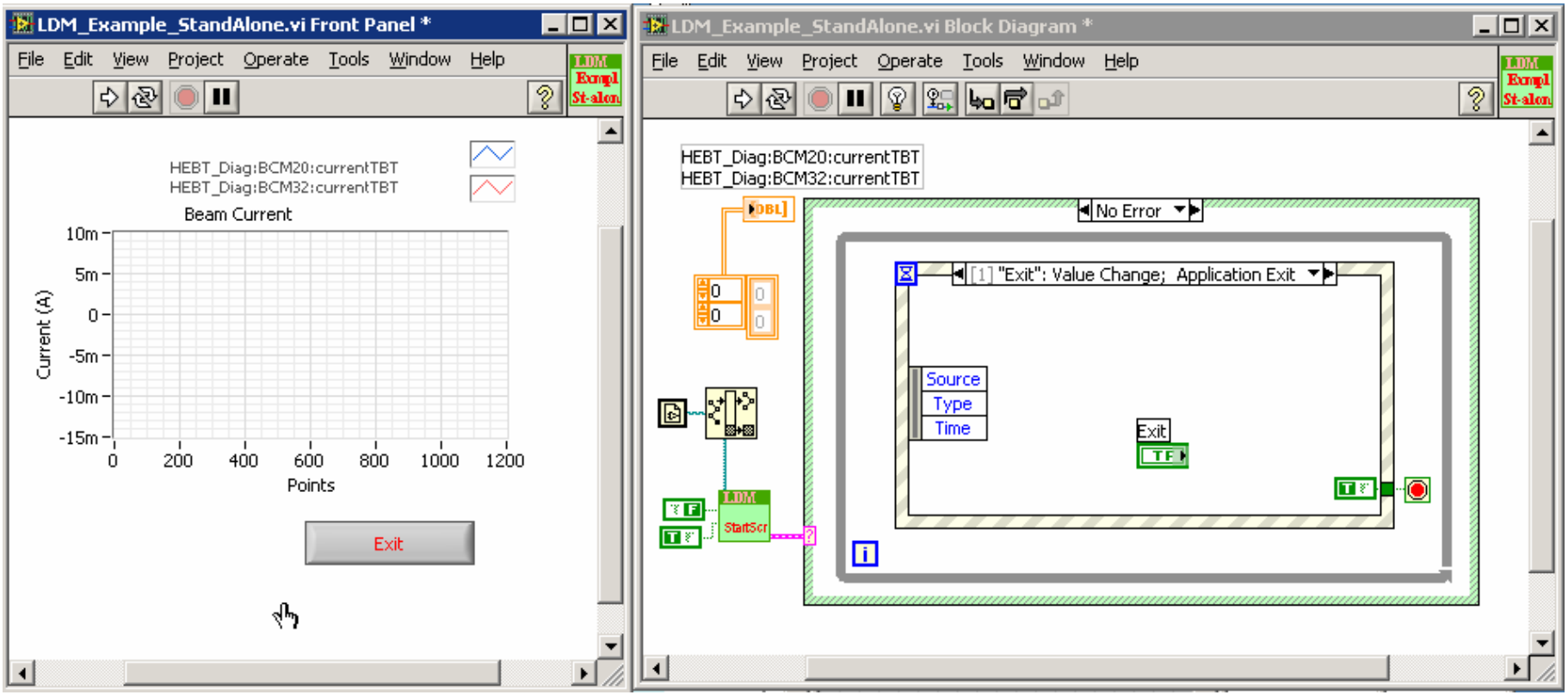
Graphical programming
•Processing routines
•Graphs/Plots

Accelerator Controls

Automatic PV Generation

- Adding a PV is simple, just add a control to LabVIEW front panel, and then edit one field.
- New method generates PVs automatically at runtime.
- Adding a PV now takes around 2 minutes on average.
- Not prone to error.
- Currently supports scalar numbers, one dimensional arrays of numbers, and it will parse down into clusters.

LabVIEW Display Manager

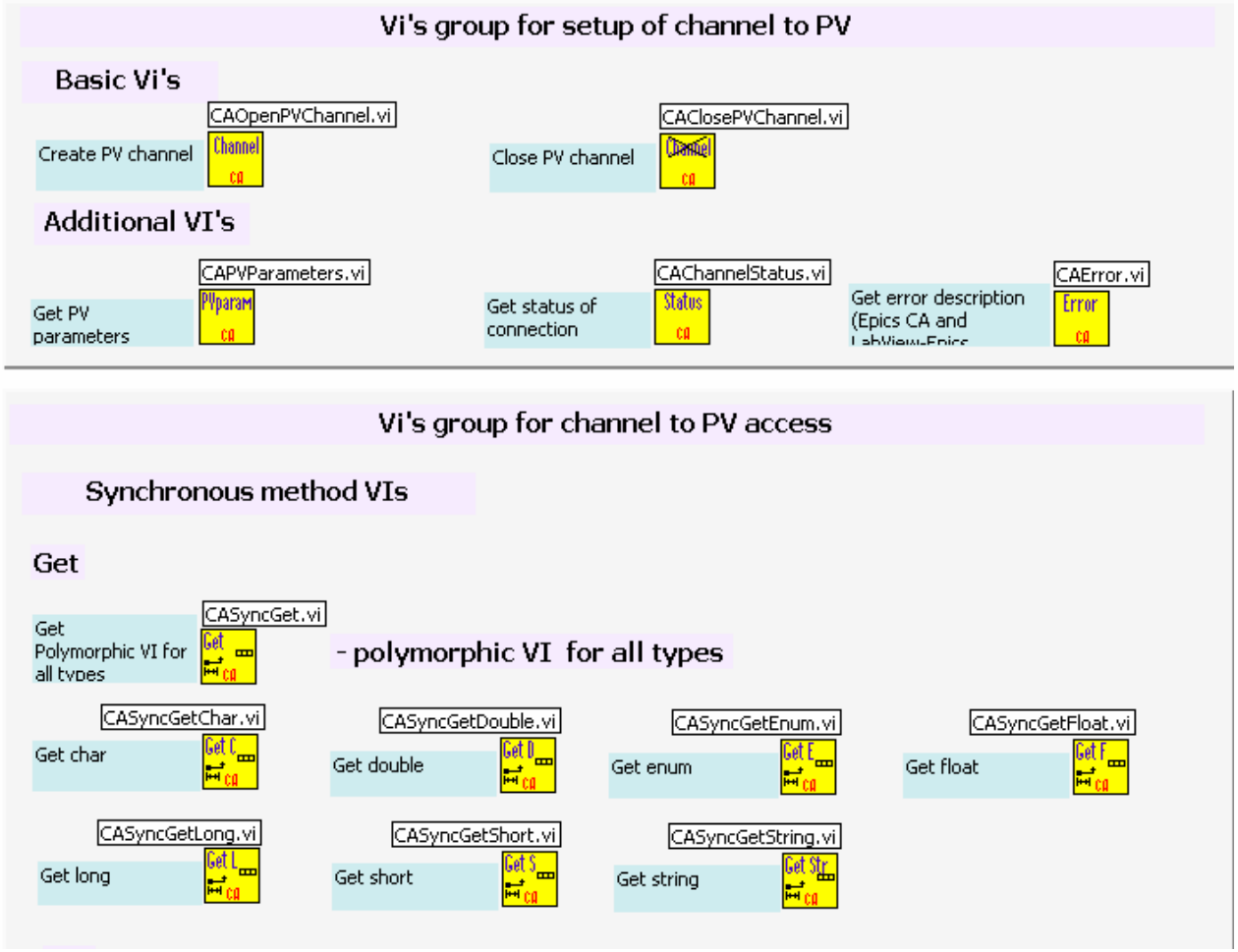


- Name a graph, control, scalar display after a PV then run.
- Analysis can be added to the code
- Implementation: LabVIEW can ask about its program, e.g. what are the parts on my panel, refer to these parts and send data to these parts

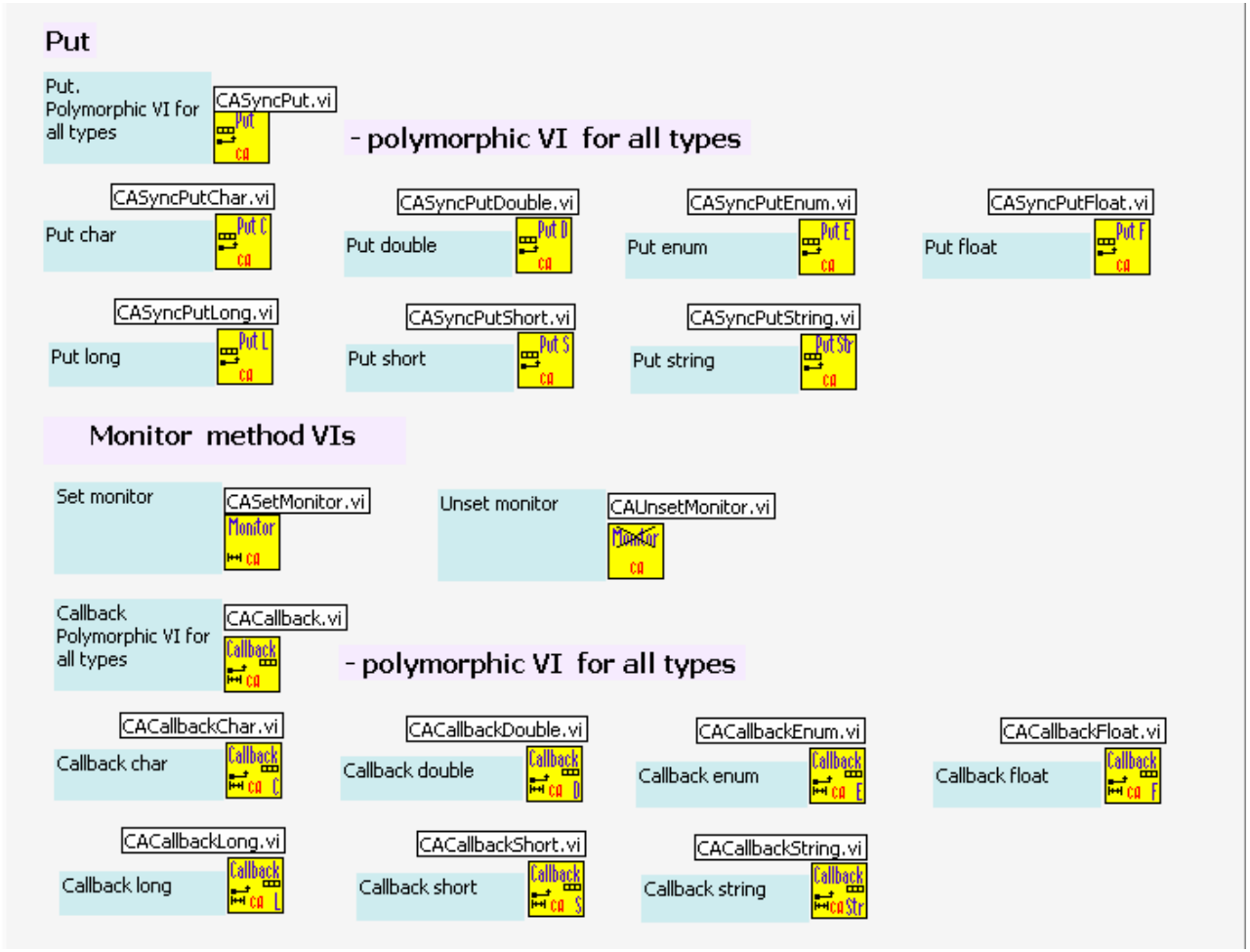
LabVIEW Channel Access Client

Developed by Andrei Liyu to Access PVs.

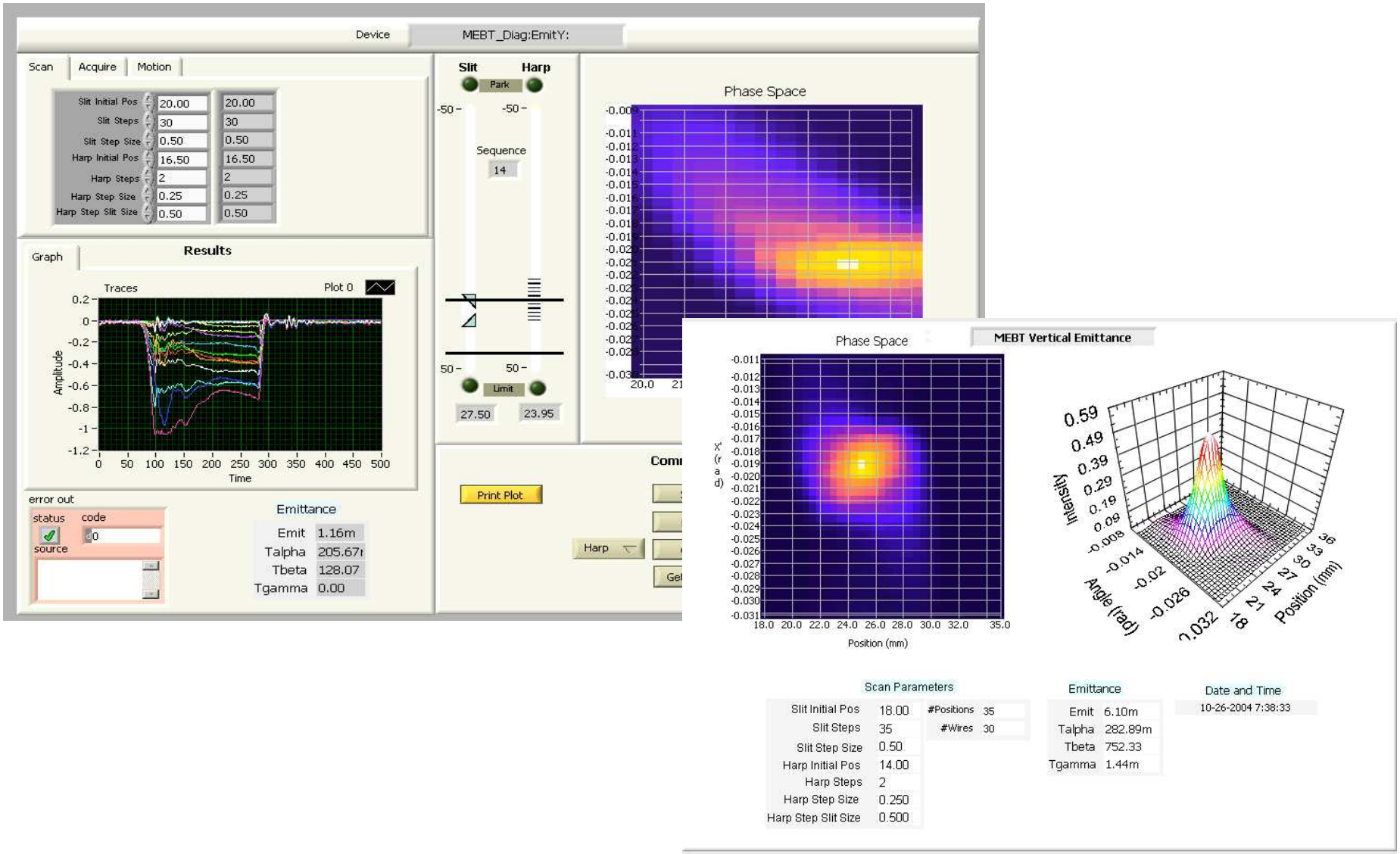
(monitoring, scan, set)



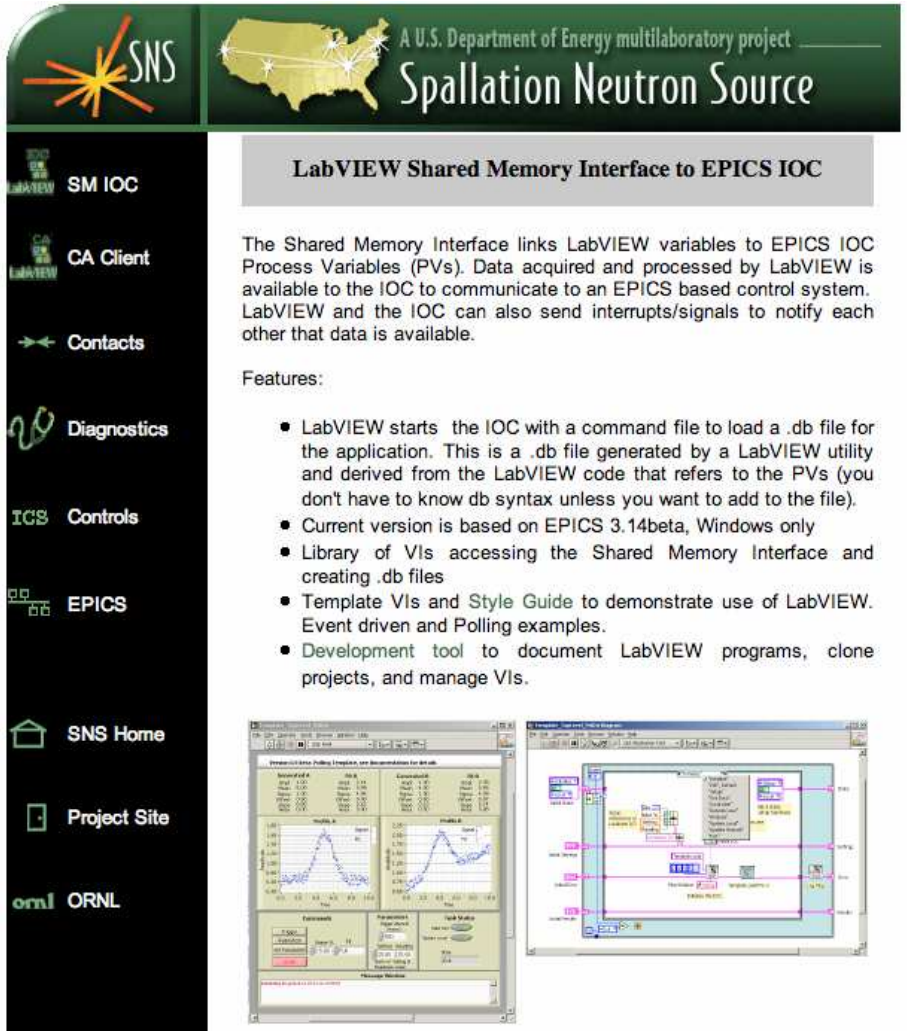
LabVIEW Channel Access Client



Emittance scanner CA Client



LabVIEW/EPICS on the Web



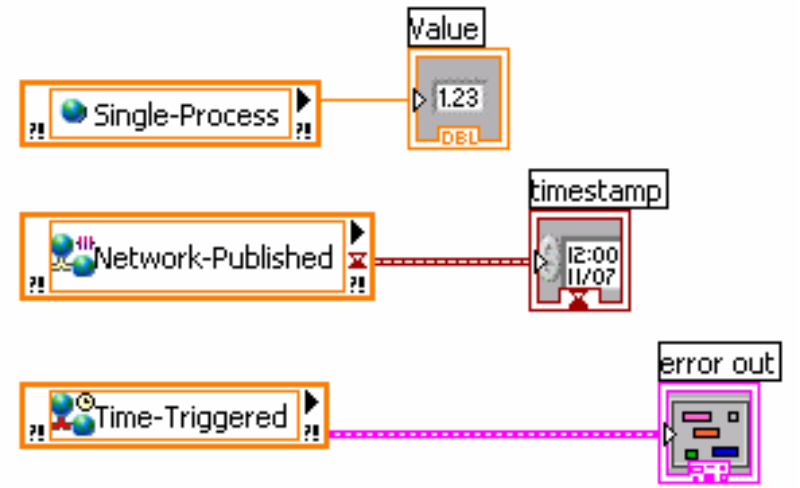
Many people from labs have requested the SNS LabVIEW/EPICS interface (France, Germany, Italy, Korea, U.S., China, etc)

http://www.sns.gov/diagnostics/documents/epics/LabVIEW/SNS_LabVIEWEPICS.html#Top
http://www.sns.gov/diagnostics/documents/epics/Downloads/downloads.html

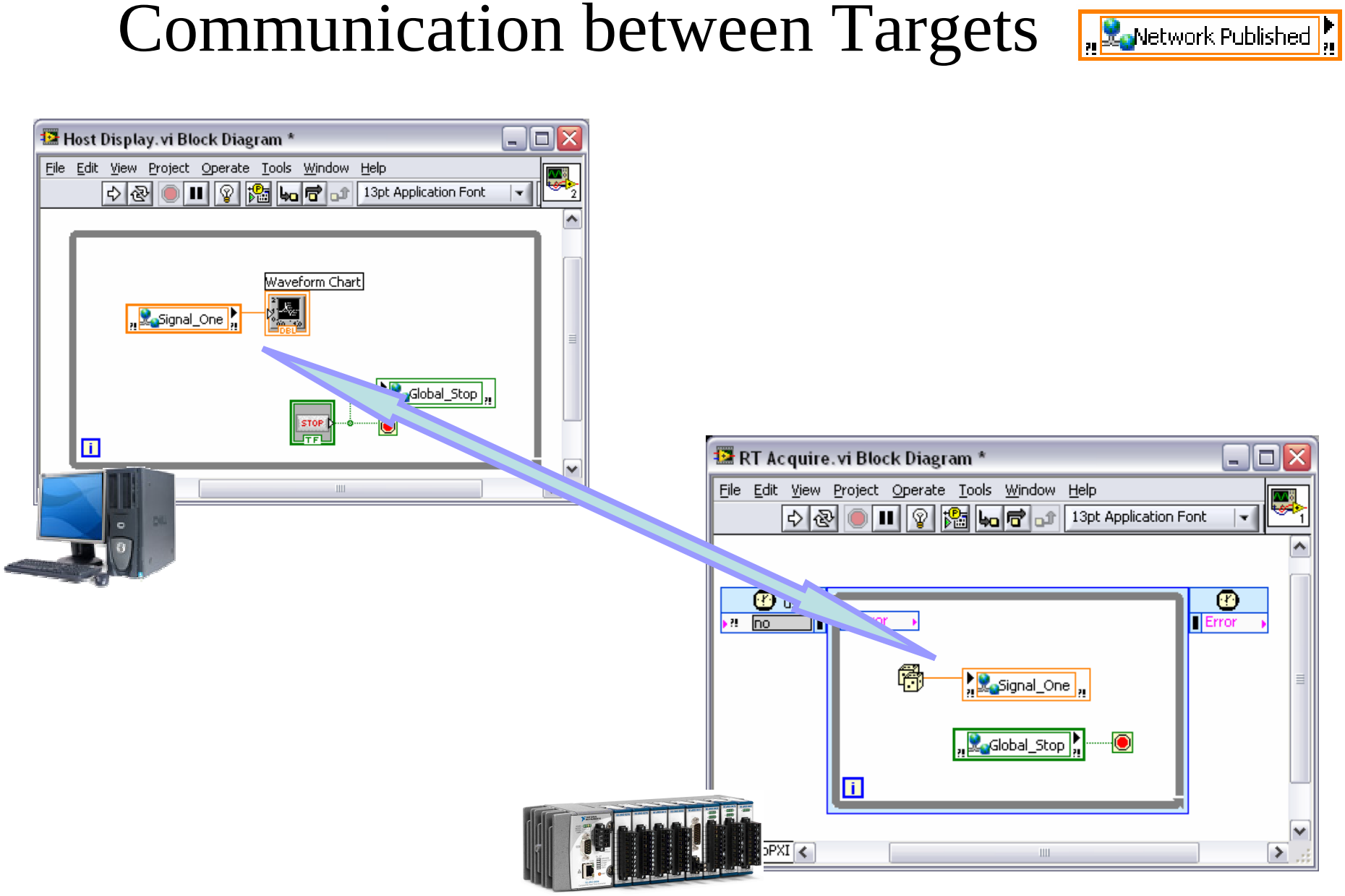
Looking Forward

Shared Variable in LabVIEW 8

- Single-Process
  - Use instead of Global Variable
- Network-Published
  - Available to any node
- Time-Triggered
  - Deterministic Communication



Communication between Targets



I/O Server in LabVIEW 8

- An I/O Server is a plug-in to the shared variable engine
- An I/O Server could be created for the CA (Channel Access) Protocol